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Additions to Late Cretaceous Shallow-Marine Gastropods from California

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Abstract. Two new genera and six new species of shallow-marine Late Cretaceous gastropods are reported from California. The trichotropid *Astandes*? Wade, 1917, formerly a monotypic genus restricted to the Maastrichtian of Tennessee, Wyoming, Montana, and Colorado, is represented by a new species of Turonian age. Two new genera of fasciolariids, the Turonian ***Mylecoma*** and the Coniacian ***Micasarcina,*** are both represented by single new species. The fasciolariid *Plectocion* Stewart, 1927, formerly a monotypic genus restricted to the Coniacian and Santonian of California, is represented by a new species of early Campanian age. The volutid *Fusivoluta* von Martens, 1902, formerly known only as a modern-day genus restricted to deep waters, is represented by a new species of early Santonian age. The mathildid *Echinimathilda* Sohl, 1960, formerly restricted to the Campanian and Maastrichtian of Mississippi is represented by a new species of Coniacian age.

Restudies of the Coniacian and Santonian fasciolariid *Plectocion curvirostris* (Gabb, 1864) and the Turonian pseudomelaniid *Liocium punctatum* Gabb, 1869, are included. The early Campanian *Faunus marcidulus* White, 1889, is reassigned to genus *Liocium* Gabb, 1869.

INTRODUCTION

Late Cretaceous, shallow-marine gastropod faunas from the Pacific slope of North America remain understudied. This paper describes or discusses nine species, six of which are new, and proposes two new genera. New taxa proposed are the trichotropid *Astandes*? ***salsa,*** sp. nov.; the fasciolariids *Plectocion* **montis,** sp. nov, ***Micasarcina vallis,*** gen. & sp. nov., and ***Mylecoma vacca,*** gen. & sp. nov; the volutid *Fusivoluta* ***cretacea,*** sp. nov.; and the mathildid *Echinimathilda* **querna,** sp. nov.

A few previously named, but poorly known taxa are also discussed and illustrated. Before this present work, both the pseudomelaniid *Liocium* Gabb, 1869, and the fasciolariid *Plectocion* Stewart, 1927, had been monotypic genera consisting of *Liocium punctatum* Gabb, 1869, and *Plectocion curvirostris* (Gabb, 1864), respectively. Both species had never received detailed study, thus they are included here with updated stratigraphic information and more illustrations to more fully document their morphology. In addition, *Faunus marcidulus* White, 1889, is reassigned to genus *Liocium,* and photographs of this species are provided for the first time.

All of the gastropods treated in this paper are from east of Redding or from the Big Chico Creek area, both in northern California. *Astandes*? ***salsa*** and *Fusivoluta* **cretacea** are also from the Santa Ana Mountains, southern California. Figure 1 shows pertinent geographic areas. Many of the specimens were collected by W. P. Popenoe, who worked on the rich Late Cretaceous molluscan faunas of the Redding area. Figure 2 shows the geologic age range of each species, with the entire interval of time involved encompassing the Turonian to early middle Campanian.

The classification system used here generally follows that of Ponder and Warén (1988). Abbreviations used for catalog and locality numbers are: ANSP, Academy of Natural Sciences of Philadelphia; CIT, California Institute of Technology, Pasadena [collections now housed at LACMIP]; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCLA, University of California, Los Angeles [collections now housed at LACMIP]; USNM, United States National Museum, Washington, D.C.

STRATIGRAPHY

The ages and depositional environments of most of the formations and members cited in this paper have been summarized in recent papers by Saul (1988), Squires & Saul (2001), and Saul & Squires (in press). Stratigraphic information mentioned below concerns either those rock units not discussed in recent literature or additional pertinent biostratigraphic details. The following stratigraphic units are listed from oldest to youngest.

Redding Formation. The area that pertains to this for-

Popenoe 1943	Jones et al., 1978	Haggart, 1986	This Paper	B
VI	not addressed	Oak Run Cgl. = V locally ?— — —?	VI	Santonian
V		Hooten Gulch Mudstone Mbr. = IV = VI, but not V	V	
IV		?— — —?	IV	Coniacian
III	Melton Sandstone Fm.	Bear Creek Sandstone Mbr. = III = V locally	Melton Sandstone Mbr.	Turonian
II	Frazier Siltstone Fm.	Frazier Siltstone Mbr.	Frazier Siltstone Mbr.	
I	Bellavista Sandstone Fm.	Bellavista Sandstone Mbr.	Bellavista Sandstone Mbr.	

Figure 1. A. Index map of the place names mentioned in text. B. Review of nomenclatural history of the stratigraphy of the Redding Formation, east of Redding.

mation is east of Redding, Shasta County, northern California (Figure 1A). The formation consists of several shallow-marine members deposited during the Turonian to Santonian stages, and the nomenclatural history of these members is shown in Figure 1B. Popenoe (1943) subdivided the Redding Formation into Members I to VI, and this convention was also utilized by Murphy et al. (1957), Matsumoto (1959), Matsumoto & Popenoe in Matsumoto (1960), and Trujillo (1960). The outcrop distributions of Members V and VI were modified somewhat by Murphy et al. (1957:pl. 3) and Matsumoto & Popenoe in Matsumoto (1960:fig. 2). Members I to III were named by Jones et al. (1978), and Haggart (1986) named three overlying members. His Bear Creek Sandstone Member includes the Melton Sandstone of Jones et al. (1978). Comparison of the geologic map in Haggart (1986:fig. 4) with the geologic map in Matsumoto & Popenoe in Matsumoto (1960:fig. 2) revealed that Haggart's Bear Creek Sandstone Member also includes Member V in Hooten Gulch. Haggart's Hooten Gulch Mudstone Member includes Members IV and VI, which he regarded as equivalent and not stacked. Furthermore, Haggart's Oak Run Conglomerate Member, at the top of the Redding Formation, is a time-transgressive unit equivalent to Member V on the south side of Oak Run Creek and in the vicinity of Basin Hollow Creek. Haggart's named units, therefore, do not directly correspond to those of earlier workers.

As mentioned earlier, many of the specimens of the new taxa from the Redding area were collected by Popenoe, and the recorded-locality descriptions reflect his view of the stratigraphy. Assignment of our localities to Haggart's stratigraphic units would require a more detailed map than provided by Haggart (1986:fig. 4). Additionally, diagrams of measured sections and chronostratigraphy of Haggart's Bear Creek, Hooten Gulch, and Oak Run Conglomerate members would assist in integrating Haggart's clearly different interpretations of Redding-area geology with that of previous workers.

The Turonian ages shown on Figure 1B for the Bellavista Sandstone, Frazier Siltstone, and Melton Sandstone members are based on work by Jones et al. (1978). The ages of Members IV, V, and VI are based on work by Matsumoto (1959), Matsumoto & Popenoe in Matsumoto (1960), Popenoe (1983), Popenoe & Saul (1987), and Saul (1988).

Specimens of *Plectocion curvirostris*, ***Micasarcina vallis***, gen. & sp. nov., and *Mathilda* **querna**, sp. nov. occur in the lower part of Member IV and are associated with the ammonites *Baculites schencki* Matsumoto, 1959, and *Peroniceras shastense* Anderson, 1958, as well as

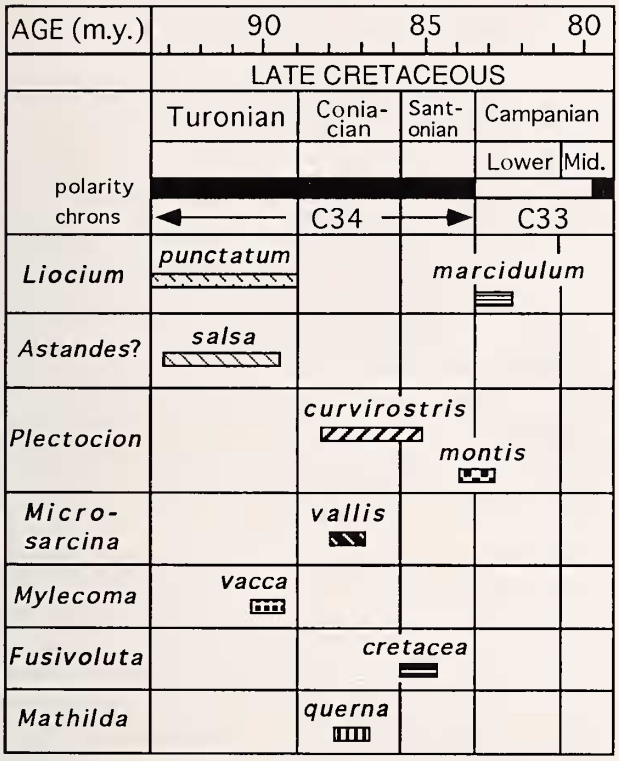


Figure 2. Chronostratigraphic positions of the new and restudied Late Cretaceous gastropods from California. Geologic ages, polarities, and chrons after Gradstein et al. (1994).

with the gastropods *Pyktes aspris* Popenoe, 1983, and *Perissitys cretacea* (Cooper, 1896), all of which are diagnostic of the Coniacian (Anderson, 1958; Matsumoto, 1959, 1960; Popenoe, 1983; Popenoe & Saul, 1987). Specimens of *P. curvirostris* also occur in Member V. Those found at LACMIP locs. 10823 and 23953 in the lowermost part of this member are associated with *Pyktes aspris* and *Perissitys cretacea* and can be assigned a late Coniacian age. Specimens of *P. curvirostris* found at several LACMIP localities (e.g., 10787, 10819, 24106) just upsection, in the remaining part of Member V, are associated with the ammonite *Baculites kirki* Matsumoto, 1959, and the gastropods *Pyktes triphyllon* Popenoe, 1983, and/or *Forsia lorda* Saul, 1988, all of which are diagnostic of the early to late Santonian (Matsumoto, 1959, 1960; Popenoe, 1983; Saul, 1988). These last-mentioned localities, just upsection from the late Coniacian ones, are more likely to be early Santonian age rather than late Santonian age.

Specimens of *Fusivoluta* **cretacea,** sp. nov. occur in Member V and in close proximity to LACMIP loc. 10794, which has yielded the gastropods *Amaea trifolia* Squires & Saul, 2003, and *Belliscala petra* Squires & Saul, 2003, both of which are indicative of the early Santonian (Squires & Saul, 2003).

Ponderosa Way Member of the Chico Formation. The area that pertains to this basal member of the Chico Formation is primarily in Big Chico and Butte creeks, Butte County, northern California (Figure 1). The lower half of this member is a cobble conglomerate with local sand lenses containing marine fossils (Saul, 1959). The upper half of the member also yields marine fossils (Saul, 1959) but is more sandy and gradational with the overlying Musty Buck Member of the Chico Formation (Saul, 1959; Haggart & Ward, 1984). Specimens of *Plectocion curvirostris* (Gabb, 1864), from LACMIP loc. 23617, in the upper half of the Ponderosa Way Member, co-occur with the ammonite *Baculites schencki* Matsumoto, 1959, which, as mentioned above, is Coniacian in age.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758

Class GASTROPODA Cuvier, 1797

Superorder CAENOGASTROPODA Cox, 1959

Order NEOTAENIOGLOSSA Haller, 1882

Suborder PTENOGLOSSA Gray, 1853

Superfamily PSEUDOMELANIOIDEA Fischer, 1885

Family PSEUDOMELANIIDAE Fischer, 1885

Discussion: Tracey et al. (1993) reported that this family is a poorly known and probably polyphyletic group of elongate, commonly rather featureless shells, and that its geologic age range is late Middle Triassic to late early Miocene. Pseudomelaniid shells are usually smooth with a flat-sided conical spire, rounded body-whorl base, smooth inner lip without folds, imperforate umbilicus (anomphalous), and wavy growth lines. These features are found in the type species of genus *Liocium* Gabb, 1869, which is discussed below. Cossmann (1909) and Wenz (1938) put *Liocium* in family Pseudomelaniidae, but Tracey et al. (1993) placed this genus, as well as *Bayania* Munier-Chalmas in Fischer, 1885, in this family with some reservation.

Both of the species of *Liocium* described below also have a small but distinct anterior notch, and this feature is not normally found in pseudomelaniids. Based on an inspection of the senior author's private collection of species of *Bayania* from Eocene beds of the Paris Basin, France, it was found that *Bayania lactae* (Bruguière, 1789; Wenz, 1938:fig. 888) has an anterior notch similar to that of *Liocium*. Not all *Bayania* species, however, have this anterior notch. Although pseudomelaniids usually have a smooth shell, *Liocium marcidulum* (White, 1889) has complex sculpture.

Family Pseudomelaniidae needs further study, but such a study is beyond the scope of this present investigation. Future work might show that *Liocium* and *Bayania* belong to a taxon of their own.

Stewart (1927) provisionally put *Liocium* in family Pyramidellidae, but *Liocium* lacks the columellar folds that typify pyramidellids.

Genus *Liocium* Gabb, 1869

Type species: *Liocium punctatum* Gabb, 1869, by monotypy; Turonian, northern California.

Diagnosis: Shell small, elongate tear-drop. Upper spire whorls flat, more mature whorls somewhat convex. Shell glossy and smooth or with complex, wrinkled-looking sculpture. Aperture ovate, anteriorly notched and posteriorly acute.

Discussion: The type species of *Liocium* resembles the eulimid *Eulima* Risso, 1826, in having a small, high-spired glossy shell with flat-sided whorls, and a slightly impressed suture bordered by a narrow, translucent band. *Eulima,* as well as other eulimids, however, does not possess the anterior notch nor the arcuate growth lines of *Liocium.*

As mentioned above, *Liocium* resembles *Bayania lactae* (Bruguière) in having an anterior notch, but *Liocium* differs from this species, as well as from other species of *Bayania,* in having more arcuate growth lines, less impressed suture, and no well-developed spiral cords. In addition, *Liocium* does not have the collabral ribs on the upper spire that *B. lactae* has.

Liocium punctatum Gabb, 1869

(Figures 3–6)

Liocium punctatum Gabb (1869:174, pl. 28, fig. 59; Cossmann, 1909:81, 96, fig. 45; Stewart, 1927:319–320, pl. 24, fig. 6; Wenz, 1938:fig. 374; Anderson, 1938:131; Jones et al., 1978:pl. 1, fig. 21).

Diagnosis: A small *Liocium* with nearly smooth shell, except for microscopically punctate spiral striae.

Description: Shell minute sized (up to 5 mm in height), elongate tear-drop. Spire high, forming approximately 43% of shell height. Pleural angle 24°. Protoconch missing approximately half a whorl or more, most mature part low and smooth, and difficult to distinguish from teleoconch. Teleoconch whorls six, sides flattish on upper spire whorls, becoming convex on more mature whorls, base of body whorl rounded. Suture barely impressed, commonly bordered anteriorly by narrow translucent (lighter) band. Whorls glossy, somewhat translucent. Penultimate whorl with one spiral row of microscopic punctae adjacent to anterior suture; other spire whorls smooth. Body whorl also with spiral rows of microscopic punctae, one just anterior to periphery and six more on anterior part of body whorl. Aperture ovate, acute posteriorly. Anterior notch small and shallow, but distinct. Outer lip projecting anteriorly and with smooth interior. Inner lip very lightly callused and smooth. Growth lines opisthocline, becoming arcuate on body whorl base.

Dimensions of holotype: Nearly complete specimen of 6.5 whorls, height 4.7 mm, diameter 1.7 mm.

Holotype: ANSP 4251.

Type locality: Exact location unknown. "Rare in the Shasta Group, south of the road from Colusa to the Hot Sulphur Springs in the first range of foot hills, Colusa County" (Gabb, 1869), near the eastern margin of the Coast Range, northern California.

Geologic age: Turonian.

Distribution: Bellavista Sandstone, Frazier Siltstone, and Melton Sandstone members of the Redding Formation, east of Redding, Shasta County, northern California; Great Valley Group, Colusa County, northern California.

Discussion: Stewart's (1927:pl. 24, fig. 6) illustration of *L. punctatum* gives the false impression that the aperture is complete, but the anterior end is missing and the outer lip is broken. Additional specimens of *L. punctatum* in the LACMIP collection were studied, and one of these (Figure 6) shows a small, but distinct anterior notch. This same specimen also shows the arcuate growth-line pattern (Figure 5), which is difficult to ascertain on most specimens because of the glossy surface.

Gabb (1869) indicated that the type locality of *L. punctatum* is in the Lower Cretaceous Shasta Group. Anderson (1938:131), however, referred Gabb's locality to the younger "Chico" beds rather than the older "Shasta" strata and commented that the type locality beds can hardly be older than late Turonian. Saul & Popenoe (1993: 367), furthermore, assigned Gabb's type locality beds to the Turonian because *L. punctatum* has not been found associated with other mollusks of Early Cretaceous age and is present in beds of Turonian age in the area east of Redding.

Stanton (1895:19) postulated that the holotype of *L. punctatum* "might possibly" be from the "Knoxville fauna." He also stated that he found abundant specimens of this species in the "Upper Horsetown fauna," but he did not give any precise locality data nor did he figure any of the specimens. The "Knoxville fauna," which stems from terminology proposed by Anderson (1902), is equivalent to the Early Cretaceous Berriasian and Valanginian stages (Saul, 1986), thus Stanton's postulated geologic age for the holotype of *L. punctatum* is not correct. The "Horsetown fauna," which also stems from Anderson (1902), roughly encompasses the Lower Cretaceous Hautervian through Albian stages (Saul, 1986), and the abundant small specimens Stanton (1895) alluded to are not *Liocium punctatum.*

Cossmann (1909) reported that *L. punctatum* is of "Aturien" [= Campanian], but this age assignment is incorrect. Tracey et al. (1993) mentioned that *Liocium* (i.e.,

Liocium punctatum) is of Cenomanian age, but that age assignment is also incorrect.

Liocium marcidulum (White, 1889)

(Figures 7–11)

Faunus marcidulus White, 1889:20–21, pl. 4, figs. 12, 13.

Diagnosis: Relatively large *Liocium* with subsutural collabral riblets as well as numerous irregularly shaped to rounded pits on penultimate and body whorls.

Description: Shell very small (up to 7 mm in height), elongate tear-drop. Spire high, forming 37% of shell height. Pleural angle 27°. Protoconch unknown. Teleoconch whorls six, sides flattish on earlier spire whorls, becoming convex on more mature whorls. Suture slightly impressed to very slightly obscured by glossy surface inductura; suture occasionally with a narrow subsutural darkish area anteriorly, developing into a low ramp on later whorls. Earliest four spire whorls smooth, glossy, somewhat translucent; approximately at whorl 4.5, scattered punctae appear on posterior half of whorl. Remaining part of teleoconch (more mature half of penultimate whorl and body whorl) with weak to very weak collabral riblets on ramp area and numerous pits (punctae) elsewhere. Collabral riblets orthocline to slightly opisthocline, numerous, and closely spaced, with interspaces about as wide as riblets. Pit distribution variable, ranging from roughly aligned vertical rows (usually on penultimate whorl) to approximately 15 obliquely spiral rows, except between ramp and shoulder, where pits can merge into irregular interspaces between collabral riblets and producing withered or wrinkled appearance. Pit density variable, ranging from somewhat widely distributed (usually on penultimate whorl) to concentrated. Aperture ovate, acute posteriorly. Anterior end very slightly twisted, anterior notch shallow but distinct. Outer lip somewhat thickened and projected anteriorly. Inner lip lightly callused and smooth.

Dimensions of holotype: Incomplete specimen of three whorls, height 6.4 mm, diameter 2.9 mm.

Holotype: USNM 20127.

Type locality: Exact location unknown. Chico Formation, probably Butte County, northern California.

Geologic age: Early Campanian, zones of *Submortoniceras chicoense* and *Baculites chicoensis*.

Distribution: Chico Formation, Ten Mile Member, Big Chico Creek, Butte County, northern California.

Discussion: The description of this species given above is based on five specimens that show generally good preservation. Three of these are from LACMIP loc. 23643 in the Ten Mile Member of the Chico Formation, and the best preserved specimen is shown in Figures 10 and 11. Ten other specimens are also from this locality, but they are badly weathered, fragmental, and consist only of spire whorls. Seven specimens of *L. marcidulus*? from LACMIP loc. 23648, also in the Ten Mile Member, are fragmental and consist only of the earliest four or fewer, smooth teleoconch whorls. More mature whorls are needed for positive specific identification.

Stewart (1927) was the first to suggest that "*Faunus*" *marcidulus* White (1889:20–21, pl. 4, figs. 12, 13) might be related to *Liocium*.

Liocium marcidulum differs from *Liocium punctatum* by having larger size, subsutural collabral riblets on mature whorls, and much more prominent and complex sculpture.

Superfamily Calyptraeoidea Lamarck, 1809

Family Trichotropidae H. & A. Adams, 1854

Genus *Astandes* Wade, 1917

Type species: *Astandes densatus* Wade, 1917, by monotypy; Late Cretaceous (Maastrichtian), Tennessee, Wyoming, Montana, and Colorado.

Diagnosis: Shell small, high turbiniform. Whorls convex with spiral cords and collabral ribs, latter becoming obsolete on siphonal neck. Anomphalous. Aperture D-shaped. Siphonal canal small but distinct. Outer lip thickened. Parietal wall callused. Growth lines prosocline.

Discussion: *Astandes* was assigned to Trichotropidae by Wenz (1940) and Sohl (1960). Beu & Maxwell (1987: 16), however, reported that *Astandes densatus* appears to belong to Cancellariidae, but they provided no discussion as to why.

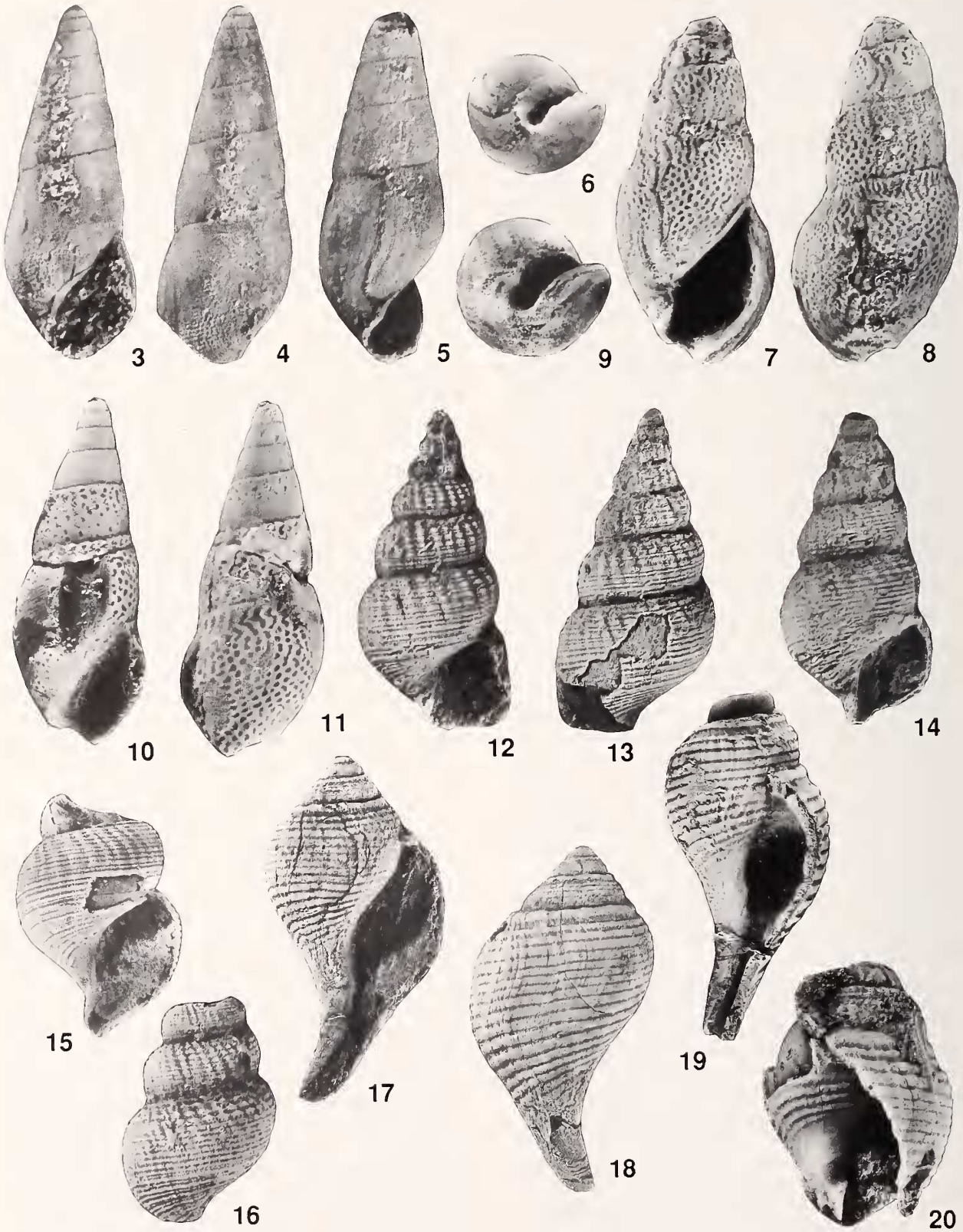
Astandes? ***salsa*** Squires & Saul, sp. nov.

(Figures 12–16)

Atresius liratus Gabb. Jones et al., 1978:pl. 1, fig. 20 [misidentified]; *non A. liratus* Gabb, 1869.

Diagnosis: *Astandes*? with weak to moderately strong beaded-cancellate sculpture and only spiral cords only anterior to body whorl periphery. Pleural angle approximately 40°. Body whorl relatively narrow.

Description: Shell small (up to 11.5 mm in height), turbiniform. Spire high, forming approximately 48% of shell height. Pleural angle approximately 40°. Protoconch unknown. Teleoconch whorls approximately seven, convex. Suture impressed. Whorls covered by numerous spiral cords and more widely spaced and stronger collabral ribs, intersections forming beaded-cancellate pattern of variable strength from weak to moderately strong. Collabral ribs extending from suture to suture on spire whorls but obsolete anterior to body whorl periphery. Body whorl base and siphonal neck having only spiral cords; spirals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on base variable in strength, slightly stronger spirals forming slight angulation on some specimens. Siphonal neck sometimes having slightly wider spiral cords, with or without single thread in interspaces. Aperture apparently oval. Siphonal canal small but distinct. Inner lip smooth with slight callus (projecting?). Growth lines prosocline.

Dimensions of holotype: Nearly complete specimen of seven whorls, height 10.7 mm, diameter 5 mm.

Holotype: LACMIP 12504.

Type locality: LACMIP loc. 10733, 40°39′55″N, 122°11′23″W.

Paratypes: LACMIP 12505 to 12507.

Geologic age: Turonian.

Distribution: Redding Formation, Bellavista Sandstone Member and Frazier Siltstone Member (type locality), east of Redding, Shasta County, northern California; Ladd Formation, Baker Canyon Member and lower part of Holz Shale Member, Santa Ana Mountains, Orange County, southern California.

Discussion: Specimens are usually weathered and abundant at every locality in the Redding Formation, but are rare at the Santa Ana Mountains localities. Usual size is approximately 7 mm in height. The strength of the beaded sculpture is variable, ranging from very low and elongate to moderately high and easily seen. The strength of the spiral sculpture is variable on the body whorl base. Some specimens have a slight basal angulation, and this angulation coincides with one or several, slightly stronger and usually slightly wider spiral cords. On some of these same specimens, the spiral cords on the siphonal neck are slightly wider and with a single thread in the interspaces. Other specimens lack an angulation, and the spiral ribbing on the siphonal neck cannot be discerned. Both variants can occur at the same locality.

Although Wade (1926) characterized *Astandes* as having a denticulate outer lip, Sohl (1967) was unable to verify the presence of denticles on the inner surface of the outer lip. According to Sohl (1960), genus *Astandes* is known with certainty only from its type species *A. densatus* Wade (1917:298–299, pl. 17, figs. 7, 8; Wade, 1926: 158, pl. 54, figs. 19, 20; Wenz, 1940:fig. 2622 [two views]; Sohl, 1960:92, unfig.; Sohl, 1967:23–24, pl. 4, figs. 1–5, 10, 12), which is of Maastrichtian age and from Tennessee, Wyoming, Montana, and Colorado. The new species resembles *A. densatus* but differs by having a narrower body whorl, beaded sculpture, weaker spiral and collabral sculpture, and more widely spaced collabral ribs. The new species also has a siphonal canal, but, because of poor preservation, it is not known if *A. densatus* has one. Until better preserved specimens of *A. densatus* are found, the new species can be only tentatively assigned to this genus.

In addition to the type species, Wade (1917, 1926) included, within his concept of *Astandes,* two European Late Cretaceous species: *Tritonium cretaceum* (Müller, 1851:47–48, pl. 5, figs. 2a, b) from the Campanian Aachen Greensand of Vaals, Germany, and *Tritonium* cf. *T. cretaceum* Müller of Kaunhowen (1897:77, pl. 9, figs. 4, 4a; pl. 13, fig. 12) from Maastrichtian strata of Belgium. These two species are rather poorly known (Sohl, 1960), but judging from illustrations, the new species differs from *T. cretaceum* by having a narrower body whorl, weaker but more numerous collabral ribs, collabral ribs obsolete anterior to body whorl periphery, and beaded sculpture. The new species differs from *T.* cf. *T. cretaceum* in the same ways, as well as in having weaker and non-sinuous spiral cords.

The new species differs considerably from *Atresius liratus* (Gabb, 1869:169, pl. 28, fig. 50; Stanton, 1895:68–69, pl. 11, fig. 6; Stewart, 1927:426, pl. 23, fig. 3; Wenz, 1940:893, fig. 2627) by having a notch on the anterior end of the aperture, collabral ribs, beaded sculpture, many more spiral cords, a columellar callus, prosocline growth lines (rather than orthocline ones, except for a slight bend at the anterior suture), and no subsutural cord. *Atresius liratus* is known from Lower Cretaceous (Hautiverian)

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Figures 3–20. Specimens coated with ammonium chloride and from east of Redding, unless otherwise stated. Figures 3–6. *Liocium punctatum* Gabb, 1869. Figures 3, 4. Holotype ANSP 4251, Colusa County, ×12.9. Figure 3. Apertural view. Figure 4. Abapertural view. Figures 5, 6. Hypotype LACMIP 12502, LACMIP loc. 24365, ×11.5. Figure 5. Left-lateral view. Figure 6. Basal view. Figures 7–11. *Liocium marcidulum* (White, 1889). Figures 7–9. Holotype USNM 20127, Butte County, ×9.4. Figure 7. Apertural view. Figure 8. Abapertural view. Figure 9. Basal view. Figures 10, 11. Hypotype LACMIP 12503, LACMIP loc. 23643, Chico Creek, ×8.7. Figure 10. Apertural view. Figure 11. Abapertural view. Figures 12–16. *Astandes*? ***salsa*** Squires & Saul, sp. nov. Figures 12, 13. Holotype LACMIP 12504, LACMIP loc. 10733, ×5.1. Figure 12. Apertural view. Figure 13. Abapertural view. Figure 14. Paratype LACMIP 12505, LACMIP loc. 10733, apertural view, ×5. Figure 15. Paratype LACMIP 12506, LACMIP loc. 10815, apertural view, ×7.5. Figure 16. Paratype LACMIP 12507, LACMIP loc. 10736, abapertural view, ×4.5. Figures 17–20. *Plectocion curvirostris* (Gabb, 1864). Figures 17,18. Hypotype LACMIP 12508, LACMIP loc. 24104, ×1.9. Figure 17. Apertural view. Figure 18. Abapertural view. Figure 19. Hypotype LACMIP 12509, LACMIP loc. 10816, apertural view, ×2.5. Figure 20. Hypotype LACMIP 12510, LACMIP loc. 8133, oblique-apertural view, ×2.8.

limestone deposits in the vicinity of Wilbur Springs, on Sulphur Creek, Colusa County, northern California (Stanton, 1895:68–69, pl. 11, fig. 6).

Etymology: The specific name is from the Latin *salsa,* meaning salt, and refers to the occurrence of this species in Salt Creek, Shasta County, northern California.

Order NEOGASTROPODA Thiele, 1929

Superfamily Muricoidea Rafinesque, 1815

Family Buccinidae Rafinesque, 1815

Subfamily Fasciolariinae J. E. Gray, 1853

Genus *Plectocion* Stewart, 1927

Type species: *Neptunea curvirostris* Gabb, 1864; Coniacian to early Santonian, east of Redding, Shasta County, northern California.

Diagnosis: Shell medium, bucciniform with prominent subsutural collar. Body whorl shoulder rounded to tabulate. Sculpture consisting of variable-strength spiral cords and collabral ribs, both of which can be obsolete on body whorl shoulder. Growth lines sinuous on body whorl shoulder. Aperture lenticular. Siphonal canal long and twisted. Outer lip somewhat crenulated. Columella with one low fold.

Discussion: *Plectocion* resembles the fasciolariid *Ornopsis* sensu stricto Wade, 1916, known from Maastrichtian deposits in the southeastern United States (Sohl, 1964). *Plectocion* differs from *Ornopsis* s. s. by having a smaller shell, no ramp, rounded rather than angulate shoulder on the body whorl, weaker but more numerous collabral ribs, and a much weaker columellar fold that is located more posteriorly.

The geologic age range of *Plectocion* is Coniacian to earliest Campanian.

Plectocion curvirostris (Gabb, 1864)

(Figures 24–27)

Neptunea curvirostris Gabb, 1864:88, 222, pl. 18, fig. 37; 1869, p. 216.

Plectocion curvirostris (Gabb). Stewart, 1927:405–406, pl. 23, figs. 12–14.

Diagnosis: *Plectocion* with swollen collar with wide spiral interspace near collar. Spiral cords wide and strong; collabral ribs predominantly on immature whorls. Body whorl shoulder can have obsolete to weak spiral threads and either short, strong collabral ribs or prominently curved growth lines.

Description: Shell medium (up to approximately 35 mm in height), bucciniform. Spire low to moderately high, forming approximately 13 to 26% of shell height. Pleural angle approximately 65°. Protoconch unknown. Teleoconch whorls approximately five (estimated), spire whorls sloping and flat sided, body whorl subglobose to moderately convex. Suture impressed and bordered by swollen collar. Sculpture consisting only of spiral cords or predominantly of spiral cords, with variable development of weak to obsolete collabral ribs. Upper spire sculpture of very fine spiral threads, in some cases subcancellate, with collabral ribs (if present) strongest. Penultimate-whorl spiral threads usually crossed by numerous and low collabral ribs, becoming obsolete toward anterior suture. Body whorl usually covered by wide and strong, flattish spiral cords; closely spaced, especially on body whorl shoulder, with interspaces widening somewhat on body whorl base; widest interspace usually between subsutural collar and posteriormost spiral cord on body whorl. Sculpture on body whorl shoulder area quite variable. Immature specimens (approximately less than 26 mm high) usually with numerous and closely spaced, short, prosocline, collabral ribs extending from subsutural collar to body whorl shoulder and producing beaded appearance where crossing collar and spiral cords. On some immature specimens (usually late juveniles, but also, rarely early juveniles) body whorl shoulder smoothish with weak to obsolete spiral threads and with either short collabral ribs or prominent growth lines. On late-stage immature specimens, collabral ribs on body whorl shoulder becoming much weaker toward outer lip. Siphonal neck narrow, with spiral ribbing obsolete. Aperture lenticular. Siphonal canal relatively long, bent to left, and slightly upturned. Outer lip with several crenulations on inside. Columella thinly callused and smooth except for one low fold (near mid-point of inner lip) extending deep into aperture and one weaker parietal fold. Growth lines usually distinct, opisthocyrt on shoulder, and parasigmoidal on remaining part of body whorl.

Dimensions of lectotype: Nearly complete specimen of approximately four whorls, height 18 mm, diameter 7.5 mm.

Lectotype: ANSP 4185.

Type locality: Exact location unknown. East of Redding, Shasta County, northern California.

Geologic age: Coniacian to early Santonian.

Distribution: CONIACIAN: Redding Formation, Members IV and V (lowermost part), east of Redding, Shasta County, northern California; Chico Formation, lower and upper parts of Ponderosa Way Member, Big Chico Creek, Butte County, northern California. LOWER SANTONIAN: Members V and VI, east of Redding, Shasta County, northern California.

Discussion: *Plectocion curvirostris* is usually abundant wherever found. At most localities it is usually well pre-

served, although the siphonal canal is nearly always broken off.

There is considerable variability in the development of collabral ribs on *P. curvirostris*. Some specimens seemingly do not have any, whereas most others, especially juveniles, have numerous, closely spaced collabrals. On late-stage juveniles, these collabrals tend to become obsolete, and no late-stage adults have collabral ribs on the body whorl. There is also variability in the development of the spiral cords. At 14 out of 17 localities, all specimens have spiral cords on the body whorl shoulder. At two localities, some specimens have weak to obsolete spiral cords on the body whorl shoulder (Figures 23, 24). These are LACMIP loc. 23617, where seven out of 50 individuals (ranging from 6 to 16 mm high) collected have the feature, and LACMIP loc. 24106, where 20 individuals (ranging from 13 to 26 mm high) out of the nearly 300 specimens collected have the feature. At both of these localities, however, there is gradation between those with and without the feature. At LACMIP loc. 10822, all 12 specimens (ranging in height from 7.5 to 25.5 mm) have weak to obsolete spiral cords on the body whorl shoulder. These different cord conditions are within the range of variation shown by the species.

Plectocion **montis** Squires & Saul, sp. nov.

(Figures 25–28)

Diagnosis: Small *Plectocion* with relatively high spire. Subsutural collar barely noded. Strong and curved collabral ribs on posterior half of tabulated body whorl; fine spiral cords on medial and anterior parts of body whorl.

Description: Shell small (up to 22.1 mm in height), buccinifform. Spire moderately high, forming approximately 18% of shell height. Pleural angle approximately 47°. Protoconch unknown. Teleoconch whorls five to six, body whorl with noded-tabulate shoulder and broadly rounded sides anterior to shoulder. Suture impressed and bordered by a prominent swollen collar bearing low nodes. Area between subsutural collar and tabulated shoulder concave, with prominent growth lines. Penultimate whorl with strong collabral ribs. Posterior half of body whorl with numerous, closely spaced, elongate, and curved-collabral ribs extending toward body whorl base; interspaces with fine spiral cords, not crossing collabral ribs and becoming obsolete toward outer lip. Spiral cords better developed on anterior part of body whorl but obsolete on neck. Aperture lenticular. Siphonal canal bent to left. Columella relatively straight, inner lip smooth. Growth lines opisthocyrt on shoulder, parasigmoidal on remaining part of body whorl.

Dimensions of holotype: Incomplete specimen of 1.5 whorls (spire missing), height 12.5 mm, diameter 8.6 mm.

Holotype: LACMIP 12514.

Type locality: LACMIP loc. 24081, 39°38′N, 121°34′50″W.

Paratype: LACMIP 12515.

Geologic age: Latest Santonian to earliest Campanian.

Distribution: UPPERMOST SANTONIAN: Chico Formation, Musty Buck Member, Big Chico Creek, northern California. LOWERMOST CAMPANIAN: Chico Formation, Pentz Road member (informal), Pentz area, northern California (type locality).

Discussion: The new species is based on three specimens. Only one has its spire, but the specimen has been abraded and the collabral ribs are not very prominent. The new species differs from *P. curvirostris* by having a stronger collar, nodes on the collar, more swollen collabral ribs that extend farther across body whorl, much finer spiral cords, and spiral cords that do not cross the collabral ribs.

Etymology: The specific name is from the Latin *montis*, meaning mountain, and refers to the occurrence of this species in the Sierra Nevada foothills.

Genus ***Micasarcina*** Squires & Saul, gen. nov.

Type species: Micasarcina vallis, sp. nov.; Coniacian east of Redding, northern California.

Diagnosis: Shell small, fusiform with two small folds on columella; posteriormost fold very weak. Subsutural cord somewhat weak to obsolete. Prominent flat-topped spiral cords. Collabral ribs obsolete anterior of medial part of body whorl.

Discussion: The new genus resembles the fossil illustrated by Taylor et al. (1983:text-fig. 3b, J) under the *nomen nudum Iscafusus*. The new genus differs from this Lower Cretaceous (upper Albian) gastropod from England by having a lower spire with fewer whorls, subsutural cord, straighter siphonal canal, and much less carinate body whorl shoulder with more closely spaced and weaker collabral ribs.

Micasarcina somewhat resembles *Plectocion*, especially in terms of the two small folds on the columella, but ***Micasarcina*** has a more slender shell, higher spire, and a much weaker to obsolete subsutural collar.

The geologic age of ***Micasarcina*** is Coniacian.

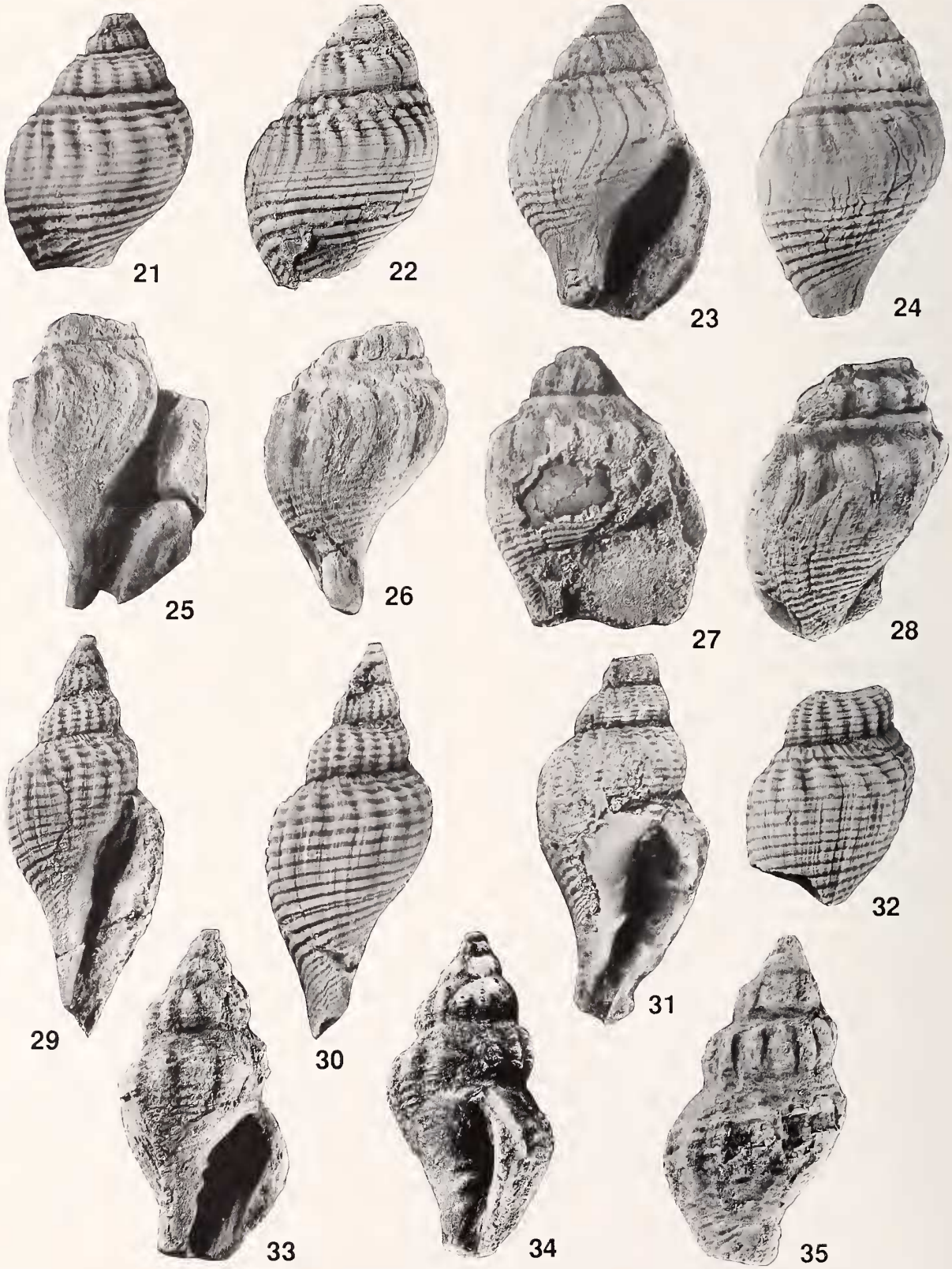
Etymology: The generic name, a combination of the Latin *mica*, meaning bit or grain, and *sarcina*, meaning bundle, is descriptive of the small size. A generic name ending in *sarcina* is of feminine gender.

Micasarcina vallis Squires & Saul, sp. nov.

(Figures 29–32)

Diagnosis: Same as for genus.

Description: Shell small (largest studied specimen in-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complete, height 19 mm, diameter 9.6 mm, and of 2.5 whorls), fusiform. Spire moderately high, forming approximately 25% of shell height. Pleural angle approximately 45°. Protoconch missing. Teleoconch whorls approximately five, convex. Suture moderately impressed. Ramp narrow, widest and more clearly demarked on body whorl; ramp bearing subsutural cord of varying strength from somewhat weak to obsolete. Earliest 1.5 teleoconch whorls smooth. Remaining part of spire and posterior third of body whorl having subcancellate sculpture, with collabral ribs slightly stronger than spiral cords; intersections with low nodes. Collabral ribs moderately strong and strongest on body whorl shoulder, closely spaced with interspaces about as wide as collabral ribs, extending from suture to suture but fading out anterior of medial part of body whorl, 18 on body whorl shoulder, 17 on penultimate whorl, and approximately 21 on ante-penultimate whorl. Spiral cords flat topped and bandlike, moderately wide, closely spaced with narrow and flat-bottomed grooved interspaces, grooves about ⅓ to ½ width of spiral bands (widest at shoulder of body whorl); about seven spiral bands on spire whorls showing sculpture. Spiral cords much closer spaced and with much narrower grooved interspaces on siphonal neck. Aperture elliptical and long, just slightly over ½ of shell height. Siphonal canal straight, with a slight twist? Columella with a smooth and moderately thick callus and two small, oblique folds; anteriormost fold about midway of aperture length; posteriormost fold in anterior parietal region and very weak. Growth lines opisthocyrt, with maximum curvature at shoulder.

Dimensions of holotype: Nearly complete specimen of five whorls, height 16.4 mm, diameter 6.6 mm.

Holotype: LACMIP 12516.

Type locality: LACMIP loc. 10816, 40°38′10″N, 122°6′W.

Paratypes: LACMIP 12517 to 12518.

Geologic age: Coniacian.

Distribution: Redding Formation, Member IV, east of Redding, Shasta County, northern California.

Discussion: This new species is based on 29 specimens, 12 of which are complete. All the specimens are from LACMIP loc. 10816. The earliest 1.5 teleoconch whorls are only preserved on the holotype, and they are smooth. This smoothness, however, might be the result of abrasion.

Etymology: The specific name is from the Latin *vallis*, meaning valley, and refers to the occurrence of this species in the Great Valley of California.

Genus *Mylecoma* Squires & Saul, gen. nov.

Type species: ***Mylecoma vacca,*** sp. nov.; Coniacian, east of Redding, northern California.

Diagnosis: Shell small, fusiform with tabulate whorls, strong spiral ribs, and three columellar folds.

Discussion: The new genus is similar to *Turehua* Marwick, 1943. According to Beu & Maxwell (1987), *Turehua* has a chronologic range of Eocene to Pliocene, a geographic distribution confined to Europe and New Zealand, and a morphology that has the least resemblance to "typical cancellariids." ***Mylecoma*** differs from *Turehua* by having three rather than two columellar folds and no growth ridges at an angle to the collabral sculpture.

The geologic age of ***Mylecoma*** is Coniacian.

Etymology: The generic name, a combination of the Greek *myle,* meaning mill, and *kome,* meaning village, refers to the occurrence of this genus in the Millville Quadrangle.

Mylecoma vacca Squires & Saul, sp. nov.

(Figures 33–37)

Diagnosis: Same as for genus.

Description: Shell small (up to 21.4 mm in height), fusiform. Spire high, forming approximately 32% of shell height. Pleural angle 55°. Protoconch unknown. Teleoconch whorls approximately six (estimated), uppermost spire whorls convex, penultimate and body whorls tabulate with shallowly concave ramp. Suture moderately im-

←

Figures 21–35. All specimens coated with ammonium chloride and from east of Redding. Figures 21–24. *Plectocion curvirostris* (Gabb, 1864). Figure 21. Hypotype LACMIP 12511, LACMIP loc. 24106, abapertural view, ×4. Figure 22. Hypotype LACMIP 12512, LACMIP loc. 24106, abapertural view, ×2.5. Figures 23, 24. Hypotype LACMIP 12513, LACMIP loc. 10822, ×2.5. Figure 23. Apertural view. Figure 24. Abapertural view. Figures 25–28. *Plectocion* **montis** Squires & Saul, sp. nov. Figures 25, 26. Holotype LACMIP 12514, LACMIP loc. 24081, ×3.8. Figure 25. Apertural view. Figure 26. Left-lateral view. Figures 27, 28. Paratype LACMIP 12515, LACMIP loc. 22406, ×3.5. Figure 27. Apertural view. Figure 28. Abapertural view. Figures 29–32. ***Micasarcina vallis*** Squires & Saul, gen. & sp. nov., LACMIP loc. 10816. Figures 29, 30. Holotype LACMIP 12516, ×4.1. Figure 29. Apertural view. Figure 30. Abapertural view. Figure 31. Paratype LACMIP 12517, apertural view, ×4.6. Figure 32. Paratype LACMIP 12518, abapertural view, ×3.5. Figures 33–35. ***Mylecoma vacca*** Squires & Saul, sp. nov., holotype LACMIP 12519, LACMIP loc. 10815, ×2.6. Figure 33. Apertural view. Figure 34. Columellar view. Figure 35. Abapertural view.

pressed. Sculpture consisting of moderately strong collabral ribs crossed by weaker but prominent spiral cords. Collabral ribs orthocline, extending from suture to suture and to body whorl base. Collabral ribs most swollen on body whorl shoulder but decreasing in strength toward outer lip, with approximately 12 on body whorl and 13 on penultimate whorl. Collabral-rib interspaces approximately as wide as ribs, with interspaces narrowing to about one third as wide as collabral ribs on body whorl shoulder. Spiral cords relatively closely spaced on spire whorls, with alternating strong and slightly weaker spiral cords on penultimate whorl (four strong ones and four weaker ones); approximately 18 spiral cords covering body whorl, from ramp area to base of neck. Aperture lenticular. Siphonal canal moderately narrow, tip missing. Outer lip mostly missing. Parietal callus thin, columellar callus thicker. Columella with three folds; posterior two stronger and closer together than third fold, middle fold strongest.

Dimensions of holotype: Nearly complete specimen of five whorls, height 21.4 mm, diameter 10.8 mm.

Holotype: LACMIP 12519.

Type locality: LACMIP loc. 10815, 40°39′05″N, 122°11′55″W.

Paratype: LACMIP 12520.

Geologic age: Turonian.

Distribution: Redding Formation, Frazier Siltstone Member, east of Redding, Shasta County, northern California.

Discussion: The new species is most similar to a specimen of *Angistoma* (*Angistoma*) *coarctata* (Beyrich) of Gründel (1997:12–13, pl. 3, fig. 5) from Oligocene deposits in Germany. The new species differs from this German specimen by having three rather than two columellar folds, stronger spiral ribs, and collabral ribs that extend onto the ramp area. Gründel (1997) placed the German specimen in *Angistoma* Sandberger, 1861 [*non Angystoma* Schumacher, 1817 = a pulmonate gastropod]. Glibert (1963), however, had designated the type species of *Angistoma* to be *Fusus ringens* Beyrich (1856:25, pl. 16, figs. 1a–b, 2a–b) from lower Oligocene (Lattorfian Stage) deposits of northern Germany, and *F. ringens* has about 10 folds on the posterior two-thirds of the columella, as well as an outer lip with a toothed-interior structure. These diagnostic features of *Angistoma* are not present on *A.* (*A.*) *coarctata* of Gründel (1997).

The new species resembles the cancellariid *Turehua lividornpis* Beu & Maxwell (1987:19–20, text fig. 2k, pls. 2c, f–j, m) from upper? Oligocene and lower Miocene beds of New Zealand. The new species differs from *T. lividornpis* by having three (rather than two) columellar folds, stronger and more numerous spiral cords, and no growth ridges at an angle to the collabral sculpture.

Etymology: The specific name is from the Latin *vacca,* meaning cow, and refers to the occurrence of this species in Little Cow Creek.

Family Volutidae Fleming, 1822

Subfamily Calliotectinae Pilsbry & Olsson, 1954

Genus *Fusivoluta* von Martens, 1902

Type species: *Voluta* (*Fusivoluta*) *anomala* von Martens, 1902; by subsequent designation (Smith, 1942); Recent, eastern Africa.

Diagnosis (modified after Weaver & du Pont, 1970): Shell medium sized, fusiform. Protoconch medium to large, bulbous or cylindrical, rarely with nucleus situated laterally. Spiral sculpture on some or all of the whorls and of variable strength. Siphonal fasciole absent. Aperture elongate to wide ovate. Siphonal notch weak or absent. Outer lip thin to thick and can be flared. Columella without folds, although juvenile specimens can have one anterior fold. Periostracum thin and transparent. Operculum horny.

Discussion: *Fusivoluta* is very similar to the volutids *Teramachia* Kuroda, 1931, and *Calliotectum* Dall, 1890. *Fusivoluta* differs from *Teramachia* by having less extensive and weaker collabral ribs, presence of spiral lirae, and no subsutural collar. *Fusivoluta* differs from *Calliotectum* by being of larger size, having a more elongate and slenderer shell, having weaker collabral ribs, and being covered with much stronger spiral lirae. The geologic age range of *Teramachia* is Pliocene (Ecuador and Okinawa) to Recent (Noda, 1998), and that of *Calliotectum* is Recent (Wenz, 1943).

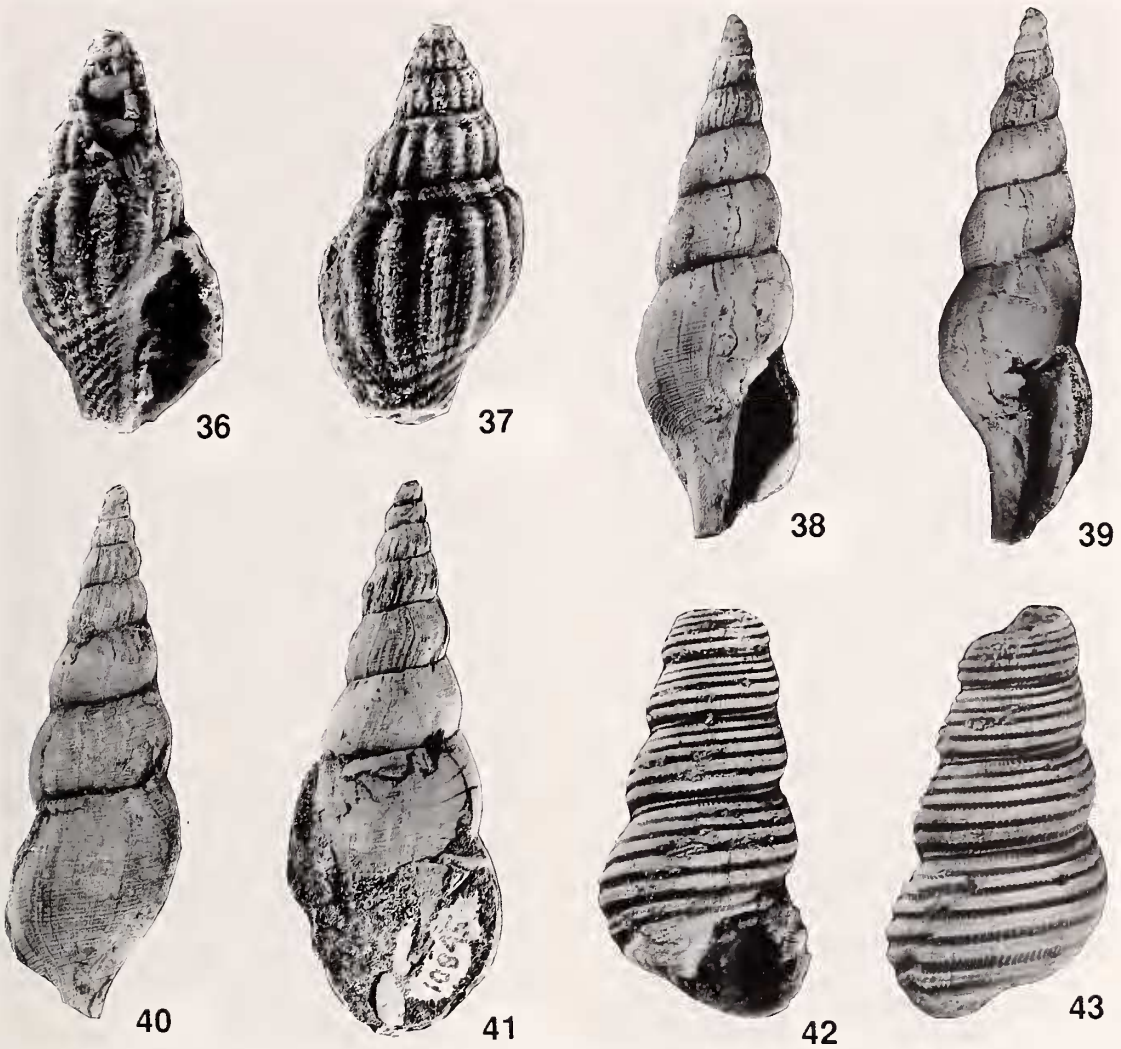
Prior to this present report, *Fusivoluta* was known only from the Recent record (Wenz, 1943). Although modern *Fusivoluta* can occur in shallow waters, it mostly occurs in deep water (71–731 m) (Weaver & du Pont, 1970).

Fusivoluta **cretacea** Squires & Saul, sp. nov.

(Figures 38–41)

Diagnosis: Medium *Fusivoluta* with distinct but very fine spiral threads covering teleoconch. Collabral riblets only moderately prominent and on upper spire whorls. Teleoconch whorls rounded (not tabulate). Outer lip showing no indications of being effuse. No folds on columella.

Description: Shell medium (up to 52.6 mm in height), fusiform. Spire high, forming approximately 47% of shell height. Thin shelled. Pleural angle 26°. Protoconch missing. Teleoconch whorls approximately eight, rounded. Suture relatively impressed. Upper spire whorls angulate, with low ramp. Sculpture consisting of very fine spiral lirae on entire teleoconch (approximately 24 on penulti-



Figures 36–43. All specimens coated with ammonium chloride and from east of Redding. Figures 36, 37. ***Mylecoma vacca*** Squires & Saul, sp. nov., paratype LACMIP 12520, LACMIP loc. 10777, ×6.7. Figure 36. Apertural view. Figure 37. Abapertural view. Figures 38–41. *Fusivoluta* **cretacea** Squires & Saul, sp. nov., LACMIP loc. 10845. Figures 38–40. Holotype LACMIP 12521, ×1.3. Figure 38. Apertural view. Figure 39. Columellar view. Figure 40. Abapertural view. Figure 41. Paratype LACMIP 12522, apertural view, ×1.6. Figures 42, 43. *Echinimathilda* ***querna*** Squires & Saul, sp. nov., holotype LACMIP 12523, LACMIP loc. 10816, ×7.1. Figure 42. Apertural view. Figure 43. Abapertural view. *Mathilda* sp. Squires & Saul, sp. nov.

mate whorl) and collabral riblets only on earlier spire whorls of teleoconch. Collabral riblets narrow, numerous, approximately 16; obsolete on middle-spire whorls and body whorl. Spiral lirae numerous, closely spaced, and with very narrow interspaces. Aperture narrow. Siphonal canal straight, fasciole absent. Outer lip thin, incomplete. Columella with thin? smooth callus, no folds apparent. Growth lines generally straight near posterior suture, opisthocline elsewhere; prominent on middle-spire whorls and on body whorl.

Dimensions of holotype: Mostly complete and of 7.5 whorls (missing tip and anterior end), height 52.6 mm, diameter 17.9 mm (crushed).

Holotype: LACMIP 12521.

Type locality: LACMIP loc. 10845, 40°38′05″N, 122°01′30″W.

Paratype: LACMIP 12522.

Geologic age: Early Santonian.

Distribution: Redding Formation, Member V, Clover Creek, east of Redding, Shasta County, northern California (type locality); Ladd Formation, ?Holz Shale Member, Santa Ana Mountains, Orange County, southern California.

Discussion: This new species is based on four specimens,

and three of these are from the type locality. One of the specimens from the type locality is the largest. Although it is a partial internal mold showing only the penultimate and body whorls, it is 46 mm in height and 22 mm in diameter. The specimen questionably from the Holz Shale Member is missing the upper part of its spire and some of its shell.

In terms of overall shape, the new species is most similar to the modern-day *Fusivoluta barnardi* Rehder (1969: 207–208, pl. 40, fig. 9; pl. 43, figs. 40–43; Weaver & du Pont, 1970:182–183, pl. 77A–B) found off the Natal coast of South Africa. The new species differs from *F. barnardi* by having much coarser spiral ribs that do not become obsolete on later whorls, as well as by having a narrower aperture whose outer lip apparently does not flare outward. In terms of sculpture, the new species is most similar to the modern-day *Fusivoluta clarkei* Rehder (1969: 206–207, pl. 40, fig. 8; pl. 43, figs. 37–39; Weaver & du Pont, 1970:193–194, pl. 77C–D), found off Mozambique. The new species differs from *F. clarkei* by having more numerous spiral threads and a narrower aperture whose outer lip apparently does not flare outward.

Etymology: The specific name refers to the Cretaceous Period.

Subclass HETEROBRANCHIA Gray, 1840

Order HETEROSTROPHA Fischer, 1885

Superfamily ARCHITECTONICOIDEA Gray, 1840

Family MATHILDIDAE Dall, 1889

Discussion: The mathildids have remained basically unchanged in their morphology since the Triassic (Bandel, 1995). Both fossil and modern mathildids are poorly studied, and today they are a deep-water group with about 130 extant nominal species in the Atlantic and Indo-Pacific oceans (Bieler, 1995).

Genus *Echinimathilda* Sohl, 1960

Type species: *Mathilda* (*Echinimathilda*) *corona* Sohl, 1960, by original designation; Campanian to Maastrichtian, Mississippi.

Diagnosis (modified after Sohl, 1960 and Dockery, 1993): Shell small to medium, turritelliform. Protoconch partly submerged and anastrophic. Teleoconch whorls shouldered and basally angulate, sides rounded. Sculpture of strong spiral cords and finer collabral riblets. Aperture semicircular to subovate. Columellar lip reflected.

Discussion: The geologic age range of *Echinimathilda* is Coniacian to Maastrichtian, and prior to this report, it was known only from Campanian and Maastrichtian strata in Mississippi (Dockery, 1993).

Echinimathilda **querna** Squires & Saul, sp. nov.

(Figures 42, 43)

Diagnosis: Small to medium *Echinimathilda* with closely spaced, wide, and flattish spiral cords. Growth lines most prominent in interspaces.

Description: Shell very small (up to approximately 8 mm in height), turritelliform. Spire high, forming approximately 58% (restored) of shell height. Shell white-translucent. Pleural angle 22°. Protoconch unknown. Teleoconch whorls seven (estimated), sides lowly convex. Suture moderately impressed, with single minute-subsutural spiral thread posterior to suture. Sculpture consisting of spiral cords and raised growth lines. Spiral cords prominent, becoming slightly stronger anteriorly on each whorl. Spiral cords flattish, closely spaced, and twice as broad as narrow interspaces. Five spiral cords on spire whorls, seven on body whorl between suture and base, and three weaker ones on flattish base of body whorl. Aperture circular. Columella smooth. Growth lines generally straight, most prominent within interspaces.

Dimensions of holotype: Incomplete specimen of 3.5 whorls, height 7.7 mm, diameter 3.5 mm.

Holotype: LACMIP 12523.

Type locality: LACMIP loc. 10816, 40°38′10″N, 122°6′W.

Geologic age: Coniacian.

Distribution: Redding Formation, Member IV, east of Redding, Shasta County, northern California.

Discussion: The above description was based on 13 specimens. Although all have good preservation of shell material, many are fragments.

The new species is most similar to *Echinimathilda parvula* (Sohl, 1960:133, pl. 18, figs. 17, 29–31; Dockery, 1993:89–90, pl. 29, figs. 4, 5; pl. 30, figs. 1–3) from Campanian and Maastrichtian strata in Mississippi. Sohl (1960) previously identified his species as *Promathilda* (*Clathrobaculus*) *parvula* Sohl, 1960, but Dockery (1993), on the basis of protoconch morphology, showed that the species belongs to *Echinimathilda*. The new species differs from *E. parvula* by having wider spiral cords, seven rather than six spiral cords on the body whorl posterior to the base, and fewer spiral cords on the base.

Etymology: The specific name is from the Latin *quernus,* meaning of oaks, and refers to the occurrence of this species on the north side of Oak Run Creek.

Acknowledgments. Lindsey Groves (LACMIP) provided access to collections, both fossil and Recent. Elana Benamy (ANSP) arranged for the loan of a holotype. Thomas Waller and Mark Florence (USNM) arranged for the loan of a holotype. Anton Oleinik (Atlantic Florida University, Boca Raton) provided valuable comments about volutids, and Richard E. Petit (North Myrtle Beach, South Carolina) provided valuable comments about

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LITERATURE CITED

Anderson, F. M. 1902. Cretaceous deposits of the Pacific coast. Proceedings of the California Academy of Sciences, Series 3, 2:1–154, pls. 1–12.

Anderson, F. M. 1938. Lower Cretaceous deposits in California and Oregon. Geological Society of America Special Papers 16:1–339, pls. 1–84.

Anderson, F. M. 1958. Upper Cretaceous of the Pacific coast. Geological Society of America Memoir 71:1–378, pls. 1–75.

Bandel, K. 1995. Mathildoidea (Gastropoda, Heterostropha) from the Late Triassic St. Cassian Formation. Scripta Geologica 111:1–83, pls. 1–19.

Beu, A. G. & P. A. Maxwell. 1987. A revision of the fossil and living gastropods related to *Plesiotriton* Fischer, 1884 (family Cancellariidae, subfamily Plesiotritoninae n. subfam.) with an appendix: genera of Buccinidae Pisaniinae related to *Colubraria* Schumacher, 1817. New Zealand Geological Survey Paleontological Bulletin 54:1–140, pls. 1–30.

Beyrich, E. 1856. Die Conchylien des norddeutschen Tertiärgebirges. Zeitschrift der Deutsche geologische Gesellschaft, Berlin, 8:21–88, 553–588.

Bieler, R. 1995. Mathildidae from New Caledonia and the Loyalty Islands (Gastropoda: Heterobranchia). Mémoires du Museum National d'Histoire Naturelle 167:595–641, figs. 1–103.

Bruguière, J. G. 1789. Encyclopédie méthodique ou par ordre de matiéres. Histoire Naturelle des Vers, des Mollusques. Vol. 1. Panckoucke: Paris. 344 pp.

Cooper, J. G. 1896. On some new Cretaceous (and Eocene?) Mollusca of California. Proceedings of the California Academy of Sciences, Series 2, 6:330–337, pls. 47,48.

Cossmann, M. 1909. Essais de Paleoconchologie Comparée, Vol. 8. Privately published: Paris, 248 pp., 4 pls.

Dall, W. H. 1890. Scientific results of explorations by the U.S. Fish Commission steamer Albatross: No. 7, Preliminary report on the collection of Mollusca and Brachiopoda obtained in 1887–88. Proceedings of the U.S. National Museum 12(773):219–362, pls. 5–14.

Dockery, D. T., III. 1993. The streptoneuran gastropods, exclusive of the Stenoglossa, of the Coffee Sand (Campanian) of northeastern Mississippi. Mississippi Department of Environmental Quality, Office of Geology, Bulletin 129:1–191, pls. 1–42.

Fischer, P. H. 1880–1887. Manuel de Conchyliologie et de Paléontologie Conchyliologique. Paris. 1367 pp.

Gabb, W. M. 1864. Description of the Cretaceous fossils. California Geological Survey, Palaeontology 1:57–243 [1864], pls. 9–32 [1865].

Gabb, W. M. 1869. Cretaceous and Tertiary fossils. California Geological Survey, Palaeontology 2:1–299, pls. 1–36.

Glibert, M. 1963. Les Muricacea et Buccinacea fossiles du Cénozoïque Étranger des Collections de l'Institut Royol des Sciences Naturelles de Belgique. Institut Royal des Sciences Naturelles de Belgique, Mémoires, Série 2, fascicule 74:34–179.

Gradstein, F. M., F. P. Agterberg, J. G. Ogg, J. Hardenbol, P. Van Veen, J. Thierry & Z. Huang. 1994. A Mesozoic time scale. Journal of Geophysical Research, Series B, 99: 24,051–24,074.

Gründel, J. 1997. Die Gastropodenfauna des Rupels von Amsdorf (westlich Halle). Palaeontographica Abteilung A 243: 1–36, pls. 1–6.

Haggart, J. W. 1986. Stratigraphy of the Redding Formation of north-central California and its bearing on Late Cretaceous paleogeography. Pp. 161–178 in P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Book 46: Los Angeles, California.

Haggart, J. W. & P. D. Ward. 1984. Late Cretaceous (Santonian-Campanian) stratigraphy of the northern Sacramento Valley, California. Geological Society of America Bulletin 95:618–627.

Jones, D. L., W. V. Sliter & W. P. Popenoe. 1978. Mid-Cretaceous (Albian to Turonian) biostratigraphy of northern California. Annales du Muséum l'Histoire Naturelle de Nice 4: xxii.1–xxii. 13.

Kaunhowen, F. 1897. Die Gastropoden der Maestrichter Kreide. Palaeontologische Abhandlungen 8:1–132, pls. 1–13.

Kuroda, T. 1931. Two new species of Volutacea. Venus 3(1): 45–49.

Martens, E. C. Von. 1902. Einige neue Arten von Meer-Conchylien aus den Sammlung der Deutschen Tiefsee-Expedition. Sitzungs-berichte der Gesellschaft Naturforschender Freunde zu Berlin, pp. 237–244.

Marwick, J. 1943. Some Tertiary Mollusca from North Otago. Transactions of the Royal Society of New Zealand 73:181–192, pls. 25–27.

Matsumoto, T. 1959. Upper Cretaceous ammonites of California. Part 1. Memoirs of the Faculty of Science, Kyushu University, Series D, Geology, (4):91–171, pls. 30–45.

Matsumoto, T. 1960. Upper Cretaceous ammonites of California. Part 3. Memoirs of the Faculty of Science, Kyushu University, Series D, Geology, Special Volume 2:1–204.

Müller, J. 1851. Monographie der Petrefacten der Aachener Kreide Formation. Vol. 2. Bonn, Germany. 88 pp., 6 pls.

Murphy, M. A., W. P. Popenoe & J. P. Albers. 1957. The Cretaceous and associated formations of the Redding area, Shasta County, California. Geological Society of Sacramento Annual Field Trip, 16 pp., 4 pls.

Noda, H. 1998. Notes on *Teramachia* (Mollusca; Gastropoda) from the Pliocene Shinzato Formation in Okinawa, southwest Japan. Annual Report of the Institute of Geoscience, the University of Tsukuba 24:71–74, fig. 1.

Ponder, W. F. & A. Warén. 1988. Appendix. Classification of the Caenogastropoda and Heterostropha—a list of the family-group names and higher taxa. Pp. 288–326 in W. F. Ponder (ed.), Prosobranch Phylogeny. Malacological Review, Supplement 4.

Popenoe, W. P. 1943. Cretaceous: east side of Sacramento Valley, Shasta and Butte counties, California. Bulletin of the American Association of Petroleum Geologists 27:306–312.

Popenoe, W. P. 1983. Cretaceous Aporrhaidae from California: Aporrhainae and Arrhoginae. Journal of Paleontology 57(4): 742–765, figs. 1–6.

Popenoe, W. P. & L. R. Saul. 1987. Evolution and classification of the Late Cretaceous-early Tertiary gastropod *Perissitys*. Natural History Museum of Los Angeles County, Contributions in Science 380:1–37, figs. 1–182.

Rehder, H. A. 1969. *Volutocorbis* and *Fusivoluta,* two genera of deepwater Volutidae from South Africa. The Veliger 11(3):200–209, pls. 40–43.

Risso, A. 1826. Histoire naturelle des principales productions de l'Europe méridionale et principalément de celles des environs de Nice et des Alpes maritimes. Vol. 4. F. G. Levrault: Paris & Strasbourg. 439 pp.

Sandberger, F. 1858–1863. Die Conchlyien des Mainzer Tertiärbeckens. Kriedel und Niedner verlagshlandlung: Wiesbaden. 468 pp., 35 pls.

Saul, L. R. 1959. Senonian mollusks from Chico Creek. M. A. thesis, University of California, Los Angeles. 170 pp.

Saul, L. R. 1986. Pacific west coast Cretaceous molluscan faunas: time and aspect of changes. Pp. 131–135 in P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Book 46: Los Angeles, California.

Saul, L. R. 1988. New Late Cretaceous and early Tertiary Perissityidae (Gastropoda) from the Pacific slope of North America. Natural History Museum of Los Angeles County, Contributions in Science 400:1–25, figs. 1–128.

Saul, L. R. & W. P. Popenoe. 1993. Additions to Pacific slope Turonian Gastropoda. The Veliger 36(4):351–388, figs. 1–138.

Saul, L. R. & R. L. Squires. In press. New Late Cretaceous cerithiform gastropods from the Pacific slope of North America. Journal of Paleontology.

Schumacher, H. C. F. 1817. Essai d'un nouveau système des habitations des vers testacés. Schultz: Copenhagen. 287 pp., 22 pls.

Smith, M. 1942. A Review of the Volutidae. Tropical Photographic Laboratory: Lantana, Florida, 127 pp., 26 pls.

Sohl, N. F. 1960. Archeogastropoda, Mesogastropoda and stratigraphy of the Ripley, Owl Creek, and Prairie Bluff formations. U.S. Geological Survey Professional Paper 331-A: 1–151 pls. 1–18.

Sohl, N. F. 1964. Neogastropoda, Opisthobranchia and Basommatophora from the Ripley, Owl Creek and Prairie Bluff formations. U.S. Geological Survey Professional Paper 331-B:1–344, pls. 1–34.

Sohl, N. F. 1967. Upper Cretaceous gastropods from the Pierre Shale at Red Bird, Wyoming. U.S. Geological Survey Professional Paper 393B:1–46, pls. 1–11.

Squires, R. L. & L. R. Saul. 2001. New Late Cretaceous gastropods from the Pacific slope of North America. Journal of Paleontology 75(1):46–55, figs. 1–6.

Squires, R. L. & L. R. Saul. 2003. New Late Cretaceous epitoniid and zygopleurid gastropods from the Pacific slope of North America. The Veliger 46(1):20–49.

Stanton, T. W. 1895. Cretaceous paleontology of the Pacific coast. The fauna of the Knoxville Beds. U.S. Geological Survey Bulletin 133:1–132, pls. 1–20.

Stewart, R. B. 1927. Gabb's California fossil type gastropods. Proceedings of the Academy of Natural Sciences of Philadelphia 78(for 1926):287–447, pls. 20–32.

Taylor, J. D., R. J. Cleevely & N. J. Morris. 1983. Predatory gastropods and their activities in the Blackdown Greensand (Albian) of England. Palaeontology 26(3):521–553, figs. 1–16.

Tracey, S., J. A. Todd & D. H. Erwin. 1993. Mollusca: Gastropoda. Pp. 131–167 in M. J. Benton (ed.), The Fossil Record 2. Chapman & Hall: London.

Trujillo, E. F. 1960. Upper Cretaceous Foraminifera from near Redding, Shasta County, California. Journal of Paleontology 34(2):290–346, pls. 43–50.

Wade, B. 1916. New genera and species of Gastropoda from the Upper Cretaceous. Proceedings of the Philadelphia Academy of Natural Sciences 68:455–471, pls. 23–24.

Wade, B. 1917. New and little known Gastropoda from the Upper Cretaceous of Tennessee. Proceedings of The Academy of Natural Sciences of Philadelphia 69:280–304, pls. 17–19.

Wade, B. 1926. The fauna of the Ripley Formation on Coon Creek, Tennessee. U.S. Geological Survey Professional Paper 137:1–272, pls. 1–72.

Weaver, C. S. & J. E. du Pont. 1970. Living Volutes—a Monograph of the Recent Volutidae of the World. Delaware Museum of Natural History, Monograph Series 1: Greenville, Delaware. 375 pp., 79 pls.

Wenz, W. 1938–1944. Gastropoda. Teil 1: Allgemeiner Teil und Prosobranchia. Pp. 1–1639, figs. 1–4211, in O. H. Schindewolf (ed.), Handbuch der Paläozoologie, Band 6. Gebrüder Borntraeger: Berlin. [reprinted 1960–1961]

White, C. A. 1889. On invertebrate fossils from the Pacific coast. U.S. Geological Survey Bulletin 51:1–102, pls. 1–14.

APPENDIX

LOCALITIES CITED

Localities are LACMIP, unless otherwise stated. All quadrangle maps listed below are U.S. Geological Survey maps. Most of the CIT localities in rocks of Turonian age in Stinking Creek, Salt Creek, and Little Cow Creek, all east of Redding, were plotted by Jones et al. (1978:fig. 5). Some of the CIT localities in Oak Run, Clover Creek, and Basin Hollow, all east of Redding, were plotted on Matsumoto (1960:fig. 2).

8133. [= CIT 1034 = LACMIP 10869 = LACMIP 24104]. Calcareous lens in shale, on S side of road, 10.5 km NE from juncture of Oak Run Road and Millville Road, and 488 m S and 396 m E of NW corner of section 16, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member IV. Age: Coniacian. Collector: W. P. Popenoe, date unknown.

10733. [= CIT loc. 1210]. Shale outcrops on right bank of Salt Creek, just upstream from prominent bend in creek, about 0.8 km N of the Alturas-Redding highway, 335 m N11°30′E from NE corner of section 3, T. 32 N, R. 3 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Frazier Siltstone Member. Age: Turonian. Collectors: W. P. Popenoe & C. Ahlroth, June 27, 1936.

10736. [= CIT loc. 1206 = LACMIP loc. 10727]. Hard fossiliferous bed in shale at N end of bluff along banks of Dry Creek, in field on E side of Bellavista-Sherman Road, 1.7 km N of Redding-Alturas Highway (U.S. 299), 686 m N6°15′E from SE corner of section 6, T. 32 N, R. 3 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Frazier Siltstone Member. Age: Turonian. Collectors: W. P. Popenoe & C. Ahlroth, 1936.

10777. [= CIT 1198]. Soft buff earthy sandstone in bed of Stinking Creek, approximately 0.4 km S of first fence across stream N of juncture with Dry Creek, 1020 m N42°W of SE corner of section 6, T. 32 N, R. 3 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Bellavista Sandstone Member. Age: Turonian. Collectors: W. P. Popenoe & C. Ahlroth, June 21, 1936.

10787. [= CIT 1006]. Near crest of N slope of divide between Basin Hollow and Clover creeks, near NE corner of NW 1/4 of section 33 and not more than 122 m S of section line, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V (lower part). Age: Early Santonian. Collectors: W. P. Popenoe & D. W. Scharf, August 8, 1931.

10794. [= CIT 1246]. Float on hillsope in Clover Creek on E side of "1000-foot hill," SE 1/4 of NE 1/4 of section 13, T. 32 N, R. 2 W, Millville quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V. Age: Early Santonian. Collector: W. P. Popenoe, August 1, 1936.

10815. [= CIT 1532]. Concretions in shale, near right bank of Little Cow Creek, 244 m N38°W of the SE corner of section 4, T. 32 N, R. 3 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Frazier Siltstone Member. Age: Turonian. Collectors: W. P. Popenoe & C. Ahlroth, July 10, 1936.

10816. [= CIT 1007]. Hard limy sandstone outcropping on lower slope of hills N of Oak Run, approximately 0.4 km S26°E of NW corner of section 16, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member IV. Age: Coniacian. Collector: W. P. Popenoe & D. W. Scharf, August 9, 1931.

10819. [= Cit 1275]. On W side of South Cow Creek, in sandstone float in stream bed just S of old-iron bridge over the creek, center of NE 1/4 of section 17, T. 31 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V. Age: Early Santonian. Collector: V. Church, August 10, 1936.

10822. [= CIT 1229]. Loose boulder picked up on slope of hill on S side of S branch of Oak Run, near NW corner of section 14, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member IV. Age: Coniacian. Collectors: W. P. Popenoe & C. Ahlroth, July 3, 1936.

10823. [= CIT 1230]. South side of section line between sections 11 and 14, on E side of Dry Creek (a tributary of Oak Run) and about 0.4 km E of SW corner of section 11, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V (lowermost part). Age: Late Coniacian. Collectors: W. P. Popenoe & C. Ahlroth, July 3, 1936.

10845. [= CIT 1245]. High shale bank with thin sandstone interbeds, right bank of Clover Creek about 0.2 km downstream from mouth of Dry Creek and about 0.6 km S56°E of NW corner of section 18, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V. Age: Early Santonian. Collector: W. P. Popenoe & V. Church, August 1, 1936.

22406. Gullies on both sides of highway approximately 0.8 km due W of Pentz, California. Cherokee Quadrangle (7.5 minute, 1949), Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: W. P. Popenoe, July 18, 1946.

23617. Concretion in hard sandstone approximately 1.5 m above streambed and approximately 15 m below highest prominent conglomerate, approximately 0.8 km upstream from Mickey's Place on W side of Big Chico Creek, NW 1/4 of the SE 1/4 of section 1, T. 23 N, R. 2 E, Paradise Quadrangle (7.5 minute, 1953). Chico Formation, Ponderosa Way Member. Age: Coniacian. Collector: R. B. Saul, August 14, 1955.

23643. Concretionary sandstone on W side of Big Chico Creek, 670 m S and 762 m W of NE corner of section 26, T. 23 N, R. 2 E, Paradise Quadrangle (7.5 minute, 1953), Butte County, northern California. Chico Formation, Ten Mile Member. Age: Early Campanian. Collectors: L. R. Saul & R. B. Saul, August, 1952.

23648. Sandstone bluff on W side of Big Chico Creek, 533 m S and 549 m E of NW corner of section 35, T. 23 N, R. 2 E, Paradise Quadrangle (7.5 minute, 1953), Butte County, northern California. Chico Formation, Ten Mile Member. Age: Early Campanian. Collectors: L. R. Saul & R. B. Saul, August, 1952.

23953. Basal conglomerate, along fault in Clover Creek, 457 m N of SW corner of section 33, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V (lowermost part) of Popenoe (1943). Age: Late Coniacian. Collector: W. P. Popenoe, August 29, 1957.

24081. Fossiliferous conglomerate approximately 2.4 km S of Pentz along Wicks-Pentz-Magalia Road and approximately 0.8 km E of road in W-flowing tributary gully to Dry Creek, near middle of section 36, T. 21 N, R. 3 E, Cherokee Quadrangle (7.5 minute, 1949), Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: A. Clark, 1935.

24104. See 8133.

24106. Fossiliferous sandstone slab on hillside N of Clover Creek in small gully flowing S to creek, approximately 670 m W of NE corner of section 23, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Member V. Age: Early Santonian. Collector: W. P. Popenoe, August 20, 1954.

24365. In fine-grained sandstone with ammonite *Romaniceras*, left bank of French Creek [= Swede Creek], approximately 152 m N and W of SE corner of section 5, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Frazier Siltstone Member. Age: Turonian. Collector: W. P. Popenoe, August 25, 1957.